TASK 2 REPORT
SELECTION OF THE
CHEMICALS AND
RADIONUCLIDES
OF CONCERN
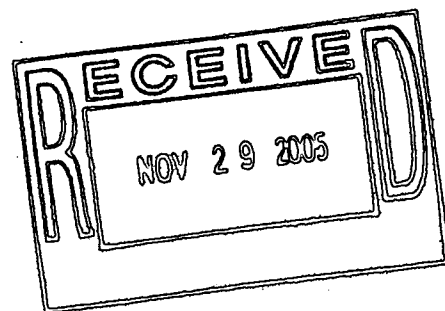
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EXECUTIVE SUMMARY

In Task 1, ChemRisk identified about 2,500 chemicals that were classified as being of moderate to high toxicity. The objective of Task 2 is to select chemicals and radionuclides that were most likely to have posed an off-site health hazard under historical routine operation of the plant.

ChemRisk identified 5 radioactive elements and their isotopes (12 radionuclides in total) as being those most likely to have posed an off-site health hazard for further study. The selection is based on the quantities of radionuclides present at the Rocky Flats Plant, effluent monitoring data and environmental sampling data.

ChemRisk devised a three-stage process to select chemicals of concern. In Stage 1, well-known environmental toxicants are identified including: carcinogens, chemicals identified by the U.S. EPA as important chronic toxicants and known human reproductive and developmental toxicants. In addition, chemicals with inventory quantities greater than 5 kg are also identified. A total of 629 chemicals are selected in Stage 1 for further screening.

In Stage 2, the toxicologic properties and inventory quantities of the chemicals selected in Stage 1 are evaluated. Chemical release assumptions and screening dispersion models that are likely to overestimate the dose received by the community (conservative models), are used to evaluate the potential of each chemical to pose an off-site health hazard. A total of 46 chemicals are selected in Stage 2 for further screening.

In Stage 3, detailed information on storage locations, annual usage rates, nature of usage, nature of toxicity and environmental fate of the chemicals selected in Stage 2 are reviewed. Based on this individual evaluation of each chemical, a total of 20 industrial

chemicals and pesticides and herbicides as a group are identified as having been of potential concern for off-site impacts.

The 5 radioactive elements and their isotopes (12 radionuclides in total), the 20 chemicals and the pesticides/herbicide group will be the subject of further project investigations to evaluate potential historic off-site exposures to these compounds.

Stage 3 Screening 47→25

Evaluation of potential chemicals of concern by their usages and environmental fates

Stage 2 screening identified 47 potential chemicals of concern. If sufficient quantities of these chemicals were released, they might adversely affect the health of off-site individuals. In Stage 3 screening, these chemicals are individually evaluated to determine their likelihood of release and quantity of release based on their storage and normal usage information. The effects of the route of release and environmental fate of some chemicals on their potential health impact are also considered.

The 47 potential chemicals of concern are divided into 2 groups based on their reported inventory quantities in 1988/89 or 1974, whichever is the largest. Chemicals in the first group have inventory quantities below 100 kg. These chemicals are believed to be mainly used in research laboratories and are not involved in production operations. Chemicals in the second group have inventory quantities above 100 kg, and are probably used in production. Table 1 shows the 2 groups of potential chemicals of concern.

Group One: Chemicals with Inventory Quantities less than 100 kg

Twenty-two potential chemicals of concern belong to this group. Most of the chemicals in this group are located and used in laboratories. Their annual usage is probably not much higher than the inventory quantities. Since these are not production chemicals, the assumption used in Stage 2 screening that 25% of the annual usage quantity was released into the environment is probably too conservative. To confirm usage, likelihood of release and quantity of release of these chemicals, the

following information was obtained from personnel working in RFP:

- verification of inventory quantities reported in 1988/89,
- verification of storage location,
- normal usage,
- disposal practice, and
- estimated release.

Table 2 summarized the information obtained. The location and inventory quantity information are confirmed for most of the chemicals. A majority of the chemicals are no longer used or have a very low annual usage rate. For those chemicals which have annual usage rates greater than the inventory quantities, their releases to the environment are estimated to be minimal. Based on the usage and release information provided in Table 2, it is unlikely for the listed chemicals to pose a significant heath hazard to off-site individuals. These chemicals are not included in the chemicals of concern list.

It is possible that some of the chemicals listed in Table 2 were used differently in the past. Table 3 compares the inventory quantities of the chemicals that are reported in both 1988/89 and 1974. The inventory quantities of many chemicals are higher in the 1974 report than in the 1988/89 report. However, most of the chemicals are listed below 10 kg. This indicates that these chemicals were probably also used in laboratories in 1974. There are exceptions, 3 chemicals, benzene, hydrazine and sodium nitrite, were reported in quantities in excess of 10 kg in 1974. Beginning in the 1970s, there is a general trend of substituting more toxic chemicals with less toxic ones whenever possible. The difference in the reported quantities of these chemicals may indicate such a change, or just a result of normal year to year fluctuation of inventory quantities.

Sodium nitrite is reported to have an inventory quantity of 10 kg in 1988/89 and 63 kg in 1974. It is used as a fertilizer and food preservative. With its relatively low toxicity and small inventory quantity, it is unlikely that sodium nitrite posed a significant health hazard to off-site individuals. Therefore, sodium nitrite is not included in the chemicals of concern list.

Benzene is a human carcinogen and hydrazine is an animal carcinogen. These 2 chemicals were reported in larger quantities in the past and might have been used in production. They are included in the chemicals of concern list.
Benzidine and propylene oxide are only reported in the 1974 inventory. As they are no longer used in RFP, no effort was made to locate their current usage and disposal information. Benzidine is a human carcinogen and propylene oxide is an animal carcinogen. Since there is no usage or release information available for these 2 chemicals, they are included in the chemicals of concern list.

Arochlors or polychlorinated biphenyls (PCBs) were reported to have an inventory quantity of 1.2 kg in the 1988/89 report. It is believed that PCBs might have been used in transformers in much greater quantities. However, any environmental release of PCBs in transformers would more likely be related to accidents and spills than to routine plant operation. For this reason, PCBs are not included in the chemicals of concern list, but are recommended to be evaluated in the accidents and incidents study.

There are 4 pesticides on the potential chemicals of concern list. Chloranil, vaponite 2 insecticide and diazinon have inventory quantity less than 100 kg. In the 1974 inventory, bromacil was reported to have an inventory quantity greater than 100 kg. It is known that there are many more pesticides

that have been used in RFP, however, there is no information about the quantities used and method of application. Furthermore, it is known that outside contractors were hired to apply pesticides in RFP. The type and quantity of pesticides used by the contractors are not listed in either 1988/89 or 1974 inventory reports. Because of the presence of information gaps and the fact that many pesticides have similar toxic effects, it is recommended that when considering the health effects of these chemicals, they should be treated as a group and not as individual compounds. Pesticides are included as a group in the chemicals of concern list.

Group Two: Chemicals with Inventory Quantities more than 100 kg

There are 25 chemicals in this group. Most of these chemicals are reported in large inventory quantities and probably used in production. Based on the similarity of some of their chemical and physical properties, they are evaluated separately in 4 subgroups:

- acids and bases
- elements
- chlorinated hydrocarbons
- others

(1) Acids and bases

There are 6 acids and bases in the potential chemicals of concern list: sodium hydroxide, potassium hydroxide, perchloric acid, hydrochloric acid, phosphoric acid and ammonia. Sulfuric acid, nitric acid and hydrofluoric acid are also used in RFP. These 3 acids are listed in Priority B list because they do not have an established health criterion nor an oral LD_{50}. In both 1974 and 1988/89 inventory reports, these 3 acids are listed in large inventory quantities and are probably used in production. The potential health impacts of these 3 acids are discussed together with the other acids and bases in the potential chemicals of concern list.

On-site and off-site neutralization of acids and bases

In general, when strong acids and bases are released into the soil or surface water, they are likely to be quickly diluted, neutralized and buffered by natural components in the environment. It is expected that if the acids and bases discussed in this section were released into the soil, groundwater or surface water, their concentrations and strengths will decrease drastically with increasing distance

from the source. Since the closest community is about 1 mile away from the RFP, these chemicals are not likely to pose a significant health impact to off-site individuals through these pathways.

Based on the 1988/89 inventory report and other documents, it is apparent that most of the acids and bases used in RFP are destroyed on-site. For example, according to the report, the major use of potassium hydroxide is for neutralization (Appendix ?). It is used to neutralize chemicals (like nitric acid) in reaction vessels, tanks and fume scrubbers. In all these processes, potassium hydroxide is consumed and rendered less toxic. According to the 1988/89 inventory report, about 70% of the total inventory quantity of potassium hydroxide is assigned for these processes. In other words, only about 30% of the potassium hydroxide reported in the inventory is available for potentially release.

Similarly, sodium hydroxide is used in regenerate demineralizer, acid neutralization, water treatment and pH adjustment (Appendix ?). According to the 1988/89 inventory report, about 90% of the total inventory quantity of sodium hydroxide is assigned for these operations. It is also known that ammonia is used to neutralize nitric acid and precipitate uranium and putonium oxides (APENs, building 771). However, it is not clear how much ammonia is neutralized on-site.

According to the 1988/89 inventory report (Appendix ?), about 80% of sulfuric acid is neutralized on site. It is mainly used to regenerate demineralizer, treat water in cooling towers, control the pH of cooling water and precipitate chemicals. Therefore, only about 20% of the sulfuric acid reported is available for potentially release.

Based on the Air Pollution Emission Notices (APEN, 1990), most nitric acid used in building 771 is either neutralized or evaporated and scrubbed by bases. These processes effectively

convert nitric acid into salts of low toxicity and drastically reduce the quantity of nitric acid available for release. APEN estimated that in 1988, about 59,890 kg of nitric acid was used building 771 and a majority of the acid is neutralized on-site. However, without knowing the use of nitric acid in other buildings, it is difficult to estimate the fraction of nitric acid available for potentially release.

Health effects of acids and bases

Acids and bases are skin and respiratory irritants; they generally cause acute health effects and do not have cumulative toxicities. As discussed in the section above, the most important transport pathway for acids and bases to pose a health hazard is through air. Sodium hydroxide, potassium hydroxide, phosphoric acid, perchloric acid and sulfuric acid are not volatile. The only mechanism that they can be transported by air is in the form of mist and aerosols. It is unlikely that sufficiently large quantities of these acid or base aerosols were generated by RFP and posed a significant health hazard to off-site individuals. Therefore, sodium hydroxide, potassium hydroxide, phosphoric acid, perchloric acid and sulfuric acid are not included in the chemicals of concern list.

Hydrochloric acid, ammonia, hydrofluoric acid and nitric acid are volatile and the vapor can potentially reach off-site individuals through air and pose a health hazard. They are separately evaluated in the following section.

Table 4 shows the predicted air concentrations of hydrochloric acid and ammonia at the RFP fence line by the air dispersion model described in Stage 2 screening. The estimated allowable quantities and the quantity ratios of these 2 chemicals are also presented. Based on the inhalation exposure scenario, the

quantity ratio of hydrochloric acid is 0.81. Therefore, it is unlikely to pose a health hazard to off-site individuals.

The predicted ammonia air concentration at the fence line is 2.1 mg/m^3. Though the predicted air concentration is higher than the U.S. EPA standard, 0.36 mg/m^3 (HEAST, 1990), it is unlikely that this chemical would pose a significant health hazard through inhalation. This is because the ammonia standard is not based on adverse health effects, but rather based on the odor threshold of humans. The level of ammonia required to produce adverse health effects is probably higher than 0.36 mg/m^3. Also, before the ammonia concentration reaches a dangerous level, the warning property of the gas would give itself away and prevent any significant damage of health.

Based on the reasons given above, hydrochloric acid and ammonia are not included in the chemicals of concern list.
Hydrogen fluoride and hydrofluoric acid are strong irritants and highly corrosive. According to RFP personnel, all processes using hydrogen fluoride are in closed systems. Therefore, it is unlikely for a substantial amount of this gas to be released into the atmosphere on a routine basis. If there were any substantial release, it is probably in an accident. According to the 1988/89 inventory report, hydrofluoric acid is used in chemical laboratories, plating, fluorination, etching of metal and glass. Through its usage, if a significant amount of hydrofluoric acid or hydrogen fluoride is escaped into the atmosphere, this chemical may have an adverse health impact on off-site individuals.

Large quantity of nitric acid is used in RFP. Many production operations involving the use of nitric acid have build-in systems to scrub the exit gas stream before release. Nevertheless, based on 1988 and 1989 SARA III reports, a substantial amount of nitric acid was released into the

atmosphere. If a large fraction of this acid is converted to nitrogen dioxide and carried off-site, it may have an adverse health impact on off-site individuals.

Due to the potential inhalation hazards of hydrofluoric acid and nitric acid, these 2 chemicals are included in the chemicals of concern list.

(2) Elements

- Assumed to be directly released into the Great Western Reservoir (smaller water body than s Standley Lake)
- Chemical would be released on a single event + were freely mixed in the reservoir (well of more likely to be a gradual release)
- The max. allowable quantity of chemical

In the 1988/89 inventory, 2097 kg of aluminum nitrate and 4336 kg aluminum nitrate solution are reported. In Stage 2 screening, the total amount of aluminum nitrate was determined by first assuming the concentration of aluminum nitrate solution to be 100% and then summing it with the inventory quantity of aluminum nitrate. The total amount is calculated to be 6433 kg. Based on the drinking water exposure scenario, the quantity ratio of aluminum nitrate was determined to be 1.15 in Stage 2 screening.   ingestion of drinking water

Upon further investigation, the aluminum nitrate solution was found to contain only 60% aluminum nitrate. As a result, the total amount of aluminum nitrate on-site is adjusted to 4699 kg instead of 6433 kg. If this adjusted inventory quantity is used for evaluation, aluminum nitrate has a quantity ratio of 0.84 instead. Therefore, aluminum nitrate is not included in the chemicals of concern list.

In Stage 2 screening, a derived RfD was calculated for cobalt by dividing its LD50 with a factor of 100,000. This approach is appropriate for chronic toxicants but is probably too conservative for essential nutrients like cobalt. The human daily dietary intake of cobalt is estimated to be about 0.04-0.05 mg/day (Water Quality Criteria). Using the exposure scenarios described in section 3.2.3.2.2, concentrations of cobalt in air and water are calculated. The average daily dose

of cobalt received by a maximally exposed individual through inhalation and drinking water ingestion are 0.029 mg/day and 0.085 mg/day, respectively (Table 5). These doses are lower than the daily dietary intake level and are unlikely to pose a health hazard to off-site individuals. For this reason, cobalt is not included in the chemicals of concern list.

Manganese is also an essential nutrient for humans. The safe and adequate dietary allowance of manganese recommended for an adult is 10 mg/day (Water Quality Criteria). Using the exposure scenarios described in section 3.2.3.2.2, concentrations of manganese in air and water are predicted. The average daily dose of manganese received by a maximally exposed individual through drinking water ingestion is 0.33 mg/day (Table 5). As this dose is below the dietary allowance, manganese compounds are not considered to pose a drinking water health hazard to off-site individuals. However, the health criterion for manganese through inhalation is about 660 times more stringent than through oral route. U.S. EPA recommends manganese in air not to exceed 0.001 mg/m^3 (U.S. EPA, 1990), which is about 5 times lower than the predicted manganese air concentration at the RFP fence line. However, it is very unlikely that anyone would spend 24 hours a day for 70 years at the fence line and with the wind blowing from the plant towards the receptor throughout that period of time. To evaluate the predicted manganese air concentration in another fashion, the manganese concentration is compared with the occupational air standard set by American Conference of Governmental Industrial Hygienists (ACGIH). As shown in Table 5, the predicted level is about 1000 time lower than the occupational air standard. Since manganese is an essential element and it is unlikely for RFP to cause off-site exposure greater than the health standard on a long term basis, manganese is not included in the chemicals of concern list.

Cadmium, nickel, chromium, beryllium and lead are potential animal and human carcinogens. Mercury is a neurotoxin and a potential reproductive and developmental toxicant. They are found in relatively large inventory quantities in RFP and are probably used in production. If significant quantities of these chemicals were released into the environment, they might adversely affect the health of off-site individuals. Based on these reasons, these 6 metal elements are included in the chemicals of concern list.

(3) Chlorinated aliphatics

There are 6 chemicals belong to this group. They are methylene chloride, tetrachloroethylene, chloroform, carbon tetrachloride, trichloroethene and 1,1,1-trichloroethane. With the exception of 1,1,1-trichloroethane, they are all suspected animal and human carcinogens. If significant quantities of these chemicals were released into the environment, they might adversely affect the health of off-site individuals. Based on these reasons, they are included in the chemicals of concern list.

(4) Others

There are 3 chemicals in group two that have not yet been evaluated. They are butadiene, formaldehyde and ethylene oxide. They are suspected animal or human carcinogens, probably involved in production. If these chemicals are released in sufficient quantities, they may pose a health impact on off-site individuals. Therefore, butadiene, formaldehyde and ethylene oxide are included in the chemicals of concern list.

Summary

A total of 22 chemicals of concern are identified in Stage 3 screening; they are listed in Table 6. Other chemicals that are evaluated in Stage 3 but not selected are included in the Priority D list (Table 7).

Evaluation of Reproductive and Developmental Toxicants

In Stage 1 screening, 12 potential reproductive and developmental toxicants were identified (Appendix E). Five of these toxicants: ethylene oxide, hexachlorobenzene, /lead/ compounds, mercury/ compounds and Aroclors were identified as chemicals of potential concern in Stage 2 screening based on health effects unrelated to reproductive or developmental effects.

The remaining 7 toxicants are evaluated in this section using an approach similar to that used for noncarcinogenic chemicals with RfDs in Stage 2 screening. Since there is no official health criterion for evaluating reproductive hazard of these chemicals, a reproductive screening dose is developed for each of them.

The majority of screening doses derived for this analysis are based on reproductive toxicity information from animal testing. The lowest observable effect level (LOEL) or no observable effect level (NOEL) is commonly used to define the dose associated with minimal or no adverse health effects in the tested animals. In the derivation of reproductive screening dose for humans, the NOEL is preferred over LOEL when both values are reported. However, when only LOEL is available for a chemical, the NOEL is estimated by dividing the LOEL by 10.

The reproductive screening dose for a chemical is determined for the purposes of this analysis by dividing the animal NOEL

by a safety factor of 100. The safety factor of 100 includes a safety factor of 10 to allow for potentially higher sensitivities of humans compared to the experimental animals and another factor of 10 to allow for differences in sensitivities among individuals.

LOEL is reported for humans for one of the chemicals. In this case, the reproductive screening dose is determined by dividing the human LOEL by a factor of 100. This includes a safety factor of 10 to estimate the NOEL and another factor of 10 to allow for differences in sensitivities among individuals.

Table ? identifies the reproductive screening dose for each 7 chemicals evaluated in this section and the reproductive toxicity information used to derive them.

An allowable quantity for each chemical is determined using the same methodology described in Section 3.2.3.2.2 using the reproductive screening dose. In most cases the drinking water exposure scenario generates a lower allowable quantity and is therefore the basis for the evaluation. However, for carbon monoxide, the inhalation exposure scenario is the most restrictive pathway and is used to determine the allowable quantity. Table ___ identifies the allowable quantities for each of the seven reproduction toxicants.

The potential reproductive health impact to off-site individuals of each chemical is evaluated by calculating its quantity ratio. This ratio is calculated by dividing the inventory quantity of a chemical by its allowable quantity. For the purposes of this screening process, if the quantity ratio of a chemical is greater than 1, it poses a potential reproductive hazard to off-site individuals. If the ratio is less than 1, then it is unlikely for the chemical to have posed a reproductive hazard to off-site individuals.

As shown in Table ?, all the chemical evaluated have a quantity ratio below 1. Therefore, it is unlikely that these chemicals have posed a reproductive hazard to off-site individuals.

Transformation

Transformation can be divided into two areas: on-site transformation and environmental transformation.

On-site transformation means the formation of new chemicals as a result of human activities in RFP either by design or as by-products. As the main purpose of RFP is to recover and refine plutonium and uranium metals, the possibility of new compound formation in these processes is briefly discussed below.

In the recovery process, plutonium bearing materials are dissolved in acids and oxidized to form PuO_4. It is then converted to PuO_2 by heating and drying. This process may involve the release of some PuO_2 particulates. In the next stage, PuO_2 is reacted with excess hydrogen fluoride gas to produce PuF_4 and SF_6. This process may involve the release of some PuF_4 particulates. Off-gas from these 2 processes are scrubbed and then passed through several high efficiency particulate air (HEPA) filters before releasing into the atmosphere. Under normal operational conditions, the amount of PuO_2 and PuF_4 released into the environment is very low. The by-product SF_6 has low toxicity and is not regulated.

We are in an early stage in understanding how released pollutants interact with other chemical and physical components in the environment. Nevertheless, we have developed some understanding about transformation of some major groups of chemicals and well-known chemicals in the environment.

In general, substances can be divided into two categories, refractory and non-refractory substances, based on their relative susceptibility to chemical transformation in the environment.

The refractory substances tend to retain their chemical composition, physical properties and toxicity in the environment for a long period of time. Some examples of this group of chemicals are metals, polychlorinated aromatics and chlorinated aliphatics.

The non-refractory substances have a relatively short life-time in the environment. They either contain reactive functional groups that react with other environmental components, or are metabolized by microorganisms in the environment. Many highly toxic chemicals contain reactive functional groups e.g., ethylene oxide, propylene oxide, benzidine, and acrylamide. They exert their toxic effects through the interaction between the reactive functional groups and biological components. Thus when their functional groups are changed through reaction or conjugated with other environmental components, they also become less toxic.

Strong acids (hydrochloric acid, sulfuric acid and nitric acid) and strong bases (ammonia, sodium hydroxide and potassium hydroxide) normally do not retain their strength for long in either soil or natural water. Organic and inorganic matters in these media have substantial buffering power and tend to resist drastic changes in pH. However, if the quantity of acid or base release is large and last over a long period of time, the buffering capacity of the system can be overwhelmed and a change of pH observed.

If nitric acid is released into the atmosphere, it may be converted to nitrogen dioxide gas. Nitrogen dioxide can be adsorbed onto suspended particulates, dissolved in water droplets or react with other pollutants in air to form smog.

Chemicals with a strong oxidizing or reducing power usually do not have a long half-live in the environment. They tend to react with other oxidants or reductants in the environment to

attain a more stable state or form. For example, hexavalent chromium can be reduced to trivalent state in natural waters by Fe (II), dissolved sulfides, and organic compounds with sulfhydryl groups (129 priority pollutants). Theoretically, MnO_2 in soil can also oxidize trivalent chromium to the hexavalent state, however, in reality this process is seldom observed in the environment. This is because at pH greater than 5, trivalent chromium quickly precipitates due to the formation of the insoluble hydroxide or oxide (129 priority pollutants). As a result, a majority fraction of trivalent chromium in the environment is immobile and separated from oxidizing agents.

There are numerous types of microorganisms in soil, lake, river and sea. Each of them is capable of using a particular type of chemicals as nutrient and source of energy. Together, they can breakdown a wide range of chemical substances to smaller and less toxic molecules. Among the organic compounds included in the potential chemicals of concern list, most of them can be biodegraded within a reasonable period of time. There are a few exceptions: hexachlorobenzene, arochlors (PCBs), polyaromatic hydrocarbons and chlorinated short chain aliphatics. These chemicals are rather resistent to biodegradation and may persist in the environment for a long period of time. It should be noted that chlorinated short chain aliphatics, like chloroform, trichloroethene and methylene chloride, do not stay in surface water or soil. Due to the relatively high vapor pressure of these chemicals, they tend to volatilize from the soil and aquatic systems to the atmosphere. Once in the troposphere, they are photo-oxidized relatively rapidly with an atmospheric lifetime of a few months.

There are examples where microorganisms increase the toxicity of a chemical through their activities. Conversion of mercury to dimethylmercury by anaerobic bacteria is a good example. In

this case, the metabolic product is more mobile and toxic than the parent substance.

Chemical reactions are generally favored by a high concentration of reacting components and a high temperature. Except for some highly reactive reagents, ambient temperature is usually too low for chemical reactions to take place. Due to dilution and dispersion, contaminant concentrations in the environment are usually very low, in the parts per million to parts per thousand ranges. As a result, it is rare to observe chemical reactions to take place in the environment to an appreciable extend.

However, when sufficient energy is given to chemicals in the environment, reactions do take place. One well-known example is the absorption of solar energy by certain organic compounds in air or water to form reactive species or free radicles. These intermediates can then decompose or react further with other chemicals in the environment to form products which may be more or less toxic than the parent compounds. Polycyclic aromatic hydrocarbons absorb solar radiation at wavelengths above 300 nm and undergo photo-oxidation. For example, benzo[a]pyrene, benzo[a]anthracene and anthracene has photo-oxidation half-lives of 1.2, 3 and 0.6 hr, respectively (129 priority pollutants). These estimates were based on laboratory measurements, in a natural aquatic system, depth and turbidity would act to reduce the rate of photo-oxidation.

Some reactive chemicals may react spontaneously with water or moisture in the environment. For example, potassium and sodium metal react with water to form hydroxides and hydrogen gas. Aluminum sulfide reacts with water to form aluminum hydroxide and hydrogen sulfide gas. However, these types of reactions are generally considered to pose a greater danger to the workers in the plant than to off-site communities.

In conclusion, because of the many chemicals used by the RFP, it is not feasible to consider the possibility of environmental transformation for every chemical. Even if there is time and budget to conduct an exhaustive search, there is little or no scientific data about environmental transformation on many chemicals. Potential environmental transformations for some of the chemicals of potential concern are considered in this section. With the possible exception of mercury and nitric acid, it is unlikely that environmental transformation would make the chemicals considered in this section more hazardous to off-site individuals.

Synergism

A synergistic effect is defined as the situation when the combined effect of two chemicals is much greater than the sum of the effect of each agent given alone. A closely related term is potentiation. It is the situation when a noneffective chemical increases the magnitude of the effect produced by another chemical.

There are numerous instances where synergism or potentiation was observed in laboratory animals. However, most of these exposure conditions are very different from human experience. For example, the laboratory animals are usually given 2 pure chemicals in relatively high concentration and for a short period of time. Humans are exposed to hundreds of chemicals in very low concentrations for 60-70 years. Often chemicals are administered to the test animals in a way that there is no relevance to human exposure conditions.

Furthermore, most screening tests for interactions employ simultaneous exposure. This approach may miss some potential interactions, for example, when the two agents being considered affect the same cellular mechanism to cause a toxic effect but have different time of onset. More specifically, dermal

exposure to an initiator like benzo[a]pyrene must take place before the exposure to the promoter (e.g., croton oil or phorbol esters) for the interaction to occur. Therefore, while animal results can suggest the potential interaction of multiple chemical exposures and give insights to the mechanism of interaction, direct extrapolation of animal data to human is difficult.

Another approach is to conduct epidemiologic studies based on human exposure experiences. There are several reported potential synergistic interactions involving tobacco smoking or ethanol drinking:

- asbestos and smoking
- radon gas and smoking
- alcohol drinking and smoking
- carbon disulfide and drinking
- some chlorinated aliphatics and drinking

The interaction between tobacco smoking and occupational exposures in the causation of lung cancer has been a highly researched area. In 1968, Selikoff et al. first reported there is a strong synergistic effect between asbestos and smoking. However, Liddell et al. (1977) and Hammond et al. (1979) studied asbestos factory workers and revealed that both additive and multiplicative models fit the data, with the multiplicative model fitting slightly better. Berry et al. (1985) followed 1250 male and 420 female asbestos factory workers and their smoking habits. The results of the study were strongly supportive of an additive response.

It is important to note that even though smoking and asbestos are among the best investigated interactions, the data are still insufficient for a clear-cut determination of the nature of their interaction (additive vs multiplicative) (Calabrese, 1991).

A considerable number of occupational epidemiologic studies have examined the possible interaction of smoking and radon exposure on the lung cancer incidence. While the result of several smaller studies supported additive, submultiplicative and multiplicative models, the largest study reported by Whittemore and McMitlan in 1983 supported a multiplicative interaction (Calabrese, 1991).

The potential synergistic interaction of alcohol consumption and other chemical exposures in causing cancer is not as well studied and highly controversial. Rothman (1975) reported that heavy drinkers have a risk of 2 to 6 times greater than nondrinkers, depending on the degree of concomitant smoking activity. However, in many instances, considerable controversy persists, and data from different studies often conflict with each other.

Studies have indicated that individuals exposed to ethanol and carbon disulfide or ethanol and carbon tetrachlorides are more susceptible to liver damage. Both carbon disulfide and carbon tetrachloride require bioactivation by certain liver enzymes to exert their liver toxicity. Alcohol consumption is known to increase the activity of these liver enzymes and therefore enhance the toxicity of these two chemicals.

In most environmental exposures, the concentration of the chemical under consideration is usually many times lower than in an occupational setting. It is argued that when the chemical dose is very low, synergistic effect or multiplicative effect is virtually indistinguishable from additive effect. This is one of the reasons why U.S. EPA recommends summing of cancer risks when evaluating the health effects of more than one carcinogen. The agency has also developed a hazard index approach to evaluate the noncarcinogenic effect of chronic toxicants. The hazard index is equal to the sum of the ratios of the subthreshold exposures to acceptable exposures. The

following equation is obtained from Risk Guidance for Superfund (volume 1), human health evaluation manual (1989).

$$\text{Hazard Index} = E_1/RfD_1 + E_2/RfD_2 + \ldots\ldots\ldots + E_i/RfD_i$$

where :

E_i = exposure level (or intake) for the ith toxicant;

$RfDi$ = reference dose for the ith toxicant; and

E and RfD are expressed in the same units and represent the same exposure period (i.e. chronic, subchronic or short-term).

It is also recommended that this equation should be applied to chemicals which produce similar toxic effects or have similar mechanisms of action.

The objective of Task 2 is to select chemicals of concern. No attempt is made to determine the release rate of chemicals, dispersion mechanisms and the actual dose received by off-site individuals. Two conservative exposure scenarios are created to compare the relative importance of the chemicals found in RFP. This comparison is made on the assumption that the chemicals are released to the same extent. Therefore, the relative importance of a chemical under such an evaluation system is dependent on its inventory quantity and toxicity only. The dose calculated in the exposure scenarios may have no relevance to the actual dose received by off-site individuals. Therefore, it is not appropriate to use these values and follow U.S. EPA's procedure in estimating the potential effect of synergisms. However, it is believed that sufficient conservatism has been built into the chemical selection process to overcome any potential synergistic effect.

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For these chemicals having an annual usage rates > the ninety quartiles, their release to the environment were estimated to be minimal.

∴ Limited use Laboratory chemicals (everything on this list) were not included in step 3 COCs.

APPENDIX L

USAGE AND ESTIMATES OF RELEASE OF GROUP ONE CHEMICALS (< 100kg)

Building	Room	Chemical	Usage	1988/1989 Inventory Quantity (kg)	Estimated Annual Usage (kg)	Disposal Method	Comments
B559	101	Acenapthene	Standard, Not Used	0.01	0	NA	
BT452B	NA	Acenapthene		0.005			
B559	101	Anthracene	Standard, Not Used	0.01	0	NA	
BT452B	NA	Anthracene		0.005			
B881	267	Anthracene, Scintillation Grade	No information	0.1	NA	NA	
T452F	NA	Benzo-a-pyrene	Not Used in years	0.002	<0.005	No release	No longer used
BT452B	NA	Chrysene		0.005			
BT452B	NA	Fluoranthene		0.005			
B559	101	Fluoranthrene	Standard, Not Used	0.01	0	NA	
B559	101	Fluorene	Standard, Not Used	0.01	0	NA	
BT452B	NA	Fluorene		0.005			
B559	101	Pyrene	Standard, Not Used	0.01	0	NA	
B881	212	Pyrene	Lab Standard	0.002	<10x qty on hand	minimal to no release	
BT452B	NA	Pyrene		0.005			
B881	224	Naphthalene	Lab Standard	0.45	<10x qty on hand	minimal to no release	No longer used
BT452B	NA	Naphthalene		0.005			
B559	101	Naphthalene	Standard, Not Used	0.01	0	NA	
B881	255	Naphthalene	Lab Standard	0.45	<10x qty on hand	minimal to no release	No longer used
B559	101	Naphthalene, Alkylate	Standard, Not Used	0.01	0	NA	
B559	101	Acrylamide	Standard, Not Used	0.01	0	NA	
B881	266	Aroclor	Lab Standard	0.016	used in minute quantities (_1)	minimal to no release	
BT452B	NA	Aroclor		0.005			
B881	262	Aroclor Mix	Lab Standard	0.002	<1ml	minimal to no release	
B881	139	Arsenic 100 ppm	Lab Standard	0.11	NA	minimal to no

						release)	
B881	137	Arsenic Acid	Lab Standard	0.45	NA	(minimal to no release)	
B559	129	Arsenic Iodide		0.11	<1x qty on hand	minimal to no release	
B559	103E	Arsenic Metal	Standard, Not Used	0.005	<1x qty on hand	minimal to no release	
B881	137	Arsenic Pentoxide	Lab Standard	0.45	NA	minimal to no release	
B559	101D	Arsenic Plas 2X	Standard, Rarely used	0.5	<5x qty on hand	minimal to no release	10% solution
B881	227	Arsenic Solution	Lab Standard	0.025	NA	minimal to no release	
B444	212A	Arsenic Trioxide	Not Used	0.46	0	NA	
B444	245C	Arsenic Trioxide	Not Used	0.5	0	NA	
B559	101D	Arsenic Trioxide		0.002	1x qty on hand	minimal to no release	
B559	129	Arsenic Trioxide	Stock supply	0.45	1x qty on hand	minimal to no release	
B779	131	Arsenic Trioxide	Not used in years	0.11	0	minimal to no release	
	137	Arsenic Trioxide	Lab Standard	0.45	NA		
B881	227	Arsenic Trioxide	Lab Standard	0.45	NA	minimal to no release	
B881	227	Arsenic Trioxide Standard	Lab Standard	0.15	NA	minimal to no release	
B559	101	Dibenzofuran	Standard, Not Used	0.01	0	NA	
B881	137	Hexachlorobenzene	Lab Standard	1	0	minimal to no release	
BT452B	NA	Hexachlorobenzene		0.005			
B779	137	Hydrazine 95%	Not used in years	0.5	0	minimal to no release	
B881	137	Hydrazine Sulfate	No information	1.2	0	NA	
B881	227	Hydrazine Sulfate	No information	0.125	0	NA	
B881	283	Methylene Dianiline	Lab Standard	1	<10x qty on hand	minimal to no release	
B559	101	O-Toluidine	Standard, Not Used	0.01	0	NA	
BT452B	NA	p-Dioxane		0.002			
B559	101	p-Dioxane	Standard, Not Used	0.01	<1x qty on hand	minimal to no release	
B444	201	p-Dioxane	Not Used	1	0	NA	
B559	101	p-Dioxane		0.516	0	NA	
B771	137	p-Dioxane	Not used in years	0.5	0	NA	
B771	137	p-Dioxane	Not used in years	1	0	NA	
B881	224	p-Dioxane	No longer used	2	0	NA	

B559	101	Quinoline	Standard, Not Used	0.01	0	NA	
B771	137	Quinoline	Not used in years	0.9	0	NA	
B771	156A	Quinoline	Not used in years	0.11	0	NA	
B881	266	Vinyl Chloride	Lab Standard	0.004	<10x qty on hand	minimal to no release	

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TABLE 3-14

COMPARISON OF 1988/89 AND 1974
INVENTORY QUANTITIES FOR GROUP ONE CHEMICALS

CAS #	Compound	1988/89 Inventory Quantity (kg)	1974 Inventory Quantity (kg)
79-06-1	Acrylamide	0.01	6.000
7440-38-2	Arsenic Compounds	3.06	4.060
71-43-2	Benzene	5.956	42.500
132-64-9y	Dibenzofuran	0.01	0.020
107-06-2	1,2-Dichloroethane	0.006	8.1
123-91-1	p-Dioxane	22.72	9.6
118-74-1	Hexachlorobenzene	1.015	1
302-01-3	Hydrazine	0.5	30.000
101-77-9	Methylene Dianaline	1.00	0.12
151-50-8	Potassium Cyanide	20.592	0.025
91-22-5	Quinoline	1.075	1.600
7632-00-0	Sodium Nitrite	10.628	63.000
95-53-4	o-Toluidine	0.01	4.400
75-01-4	Vinyl Chloride	0.004	0.200

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	TABLE 3-15

EVALUATION OF HYDROCHLORIC ACID AND AMMONIA

Chemical	Health Criteria (inhalation) (mg/kg/day)	Predicted Air Concentration[1] (mg/m³)	Allowable Quantity (kg)	Actual Inventory Quantity (kg)	Quantity Ratio
Hydrochloric Acid	0.009	0.0028	1600	1300	0.8125
Ammonia	0.1	2.1	160000	996000	6.225
1 At the fence line of RFP					

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TABLE 3-16

EVALUATION OF COBALT AND MANGANESE COMPOUNDS

DRINKING WATER EXPOSURE SCENARIO

Compound	Predicted Water Concentration (mg/l)	Average Daily Dose (mg/day)	Recommended Daily Dietary Intake (mg/day)	Oral RfD (mg/day)
Manganese Compound	0.16	0.33	10 [1]	7
Cobalt Compounds	0.04	0.085	0.1 - 0.25 [1]	NA

INHALATION EXPOSURE SCENARIO

Compound	Predicted Air Concentration (mg/m³)	Average Daily Dose (mg/day)	Occupational Standard (mg/m)3	Predicted Air Concentration/ Occupational Standard
Manganese Compounds	0.0056	0.11	5 (TWA) [2]	0.001
Cobalt Compounds	0.0014	0.029	0.05 (TWA) [2]	0.028

[1]   California State Water Resources Control Board, 1963
[2]   ACGIH, 1990-1991

TWA = 8 hour time weighed average

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TABLE 3-17

CHEMICALS OF CONCERN LIST

COCs carried forward into Test 3-18

Chemical Name
Benzidine
Propylene Oxide
Butadiene
Ethylene Oxide
Benzene
Hydrazine
Cadmium Compounds
Nickel Compounds
Chromium Compounds
Beryllium Compounds
Mercury Compounds
Lead Compounds
Methylene Chloride
Chloroform
Carbon Tetrachloride
Tetrachloroethylene
Trichloroethene
1,1,1-Trichloroethane
Formaldehyde
Nitric Acid
Pesticides/Herbicides Group

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TABLE 3-18

LIST D CHEMICALS *Evaluated in Stage 3 but not selected.*

Compound
N-Nitroso-Di-N-Propylamine
Dibenzofuran
Aroclors
Vinyl Chloride
Chloranil
Methylene Dianaline
Hexachlorobenzene
Quinoline
Arsenic Compounds
o-Toluidine
Acrylamide
PAHs
1,2-Dichloroethane
Vaponite 2 Insecticide
Potassium Cyanide
p-Dioxane
Sodium Nitrite
Diazinon
Cobalt Oxide
Hydrochloric Acid
Manganese Compounds
Perchloric Acid
Phosphoric Acid
Sodium Hydroxide
Bromacil
Potassium Hydroxide
Ammonia

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	TABLE 3-19
	RADIONUCLIDES OF CONCERN
	Americium - 241
242	Plutonium - 238, 239, 240, 241, and
	Thorium - 232
	Uranium - 233, 234, 235, and 238
	Hydrogen - 3 (tritium)

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Carried fard into Tbl 3-4

TABLE 3-8

DERIVATION OF REPRODUCTIVE SCREENING DOSE

Chemicals	Inhalation Exposure		Oral Exposure		Reproductive Screening Dose (mg/kg-day)
	LOEL (mg/m^3)[a]	NOEL (mg/m^3)[a]	LOEL (mg/kg-day)	NOEL (mg/kg-day)	
Carbon Disulfide	10 (rat) [1]	NA	NA	NA	3.39 x 10^{-3}
Coumarin	NA	NA	0.3 (human) [2]	NA	3.00 x 10^{-4}
Dinitrobenzene	NA	NA	NA	1 (rat)*[3]	1.00 x 10^{-4}
Ethylene Glycol Monoethyl Ether (2-Ethoxyethanol)	NA	190 (rat) [4]	NA	NA	6.44 x 10^{-1}
Ethylene Glycol Monomethyl Ether (2-Methoxyethanol)	NA	32 (rat) [4]	NA	NA	1.08 x 10^{-1}
Lithium	NA	NA	NA	4 (monkey) [1]	4.00 x 10^{-2}
Carbon Monoxide	100 (rabbit) [1]	NA	NA	NA	3.12 x 10^{-2}
Ethylene Oxide	evaluated in Stage 3 screening				
Hexachlorobenzene	evaluated in Stage 3 screening				
Lead	evaluated in Stage 3 screening				
Mercury Compounds	evaluated in Stage 3 screening				
PCB's (Aroclors)	evaluated in Stage 3 screening				

Note: [1] Shepard, 1989   [3] Blackburn, 1988
[2] IRIS   [4] Paustenbach, 1989
    USEPA, 1990b

•   No adverse effect was observed after a single oral dose of 10 mg/kg of 1,3 dinitrobenzene. The chronic NOEL is assumed to be one tenth of the acute NOEL.

a   When animal inhalation data are used to calculate the daily dose, the average body weight and inhalation rate for rats are taken to be 0.425 kg and 0.144 m^3/day, respectively. The average body weight and inhalation rate for rabbits are taken to be 3 kg and 0.936 m^3, respectively.

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TABLE 3-9

EVALUATION OF REPRODUCTIVE AND DEVELOPMENTAL TOXICANTS

Chemicals	Reproductive Screening Dose (mg/kg-day)	Exposure Scenario	Allowable Quantity (kg)	Inventory Quantity (kg)	Quantity Ratio
Carbon Disulfide	3.39 x10^{-3}	drinking water	5.60 x 10^{+2}	5.9	1.1 x 10^{-2}
Coumarin	3.00 x 10^{-4}	drinking water	5.60 x 10^{+1}	1.8	3.2 x 10^{-2}
Dinitrobenzene	1.00 x 10^{-2}	drinking water	5.60 x 10^{+3}	0.12	2.1 x 10^{-5}
Ethylene Glycol Monoethyl Ether (2-Ethoxyethanol)	6.44 x 10^{-1}	drinking water	5.60 x 10^{+4}	8.2	1.5 x 10^{-4}
Ethylene Glycol	1.08 x 10^{-1}	drinking water	5.60 x 10^{+4}	246	4.4 x 10^{-3}

Monomethyl Ether (2-Methoxyethanol)					
Lithium	4.00×10^{-2}	drinking water	5.60×10^{-3}	239.9	4.3×10^{-2}
Carbon Monoxide	3.12×10^{-2}	inhalation	1.60×10^{-4}	60	3.8×10^{-3}

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Arsenic.

TABLE 3-12

POTENTIAL CHEMICALS OF CONCERN LIST
Group One: Inventory Quantity < 100 kg

Believed to have been used mainly in research laboratories and not involved in production operations

CAS #	COMPOUND	QUANTITY RATIO	INVENTORY QUANTITY (KG)
621-64-7	N-Nitroso-di-N-Propylamine	1.79×10^{-2}	1.00×10^{-3}
132-64-9	Dibenzofuran	$3.57 \times 10^{+3}$	2.00×10^{-2}
92-87-5	Benzidine	$4.46 \times 10^{+1}$	2.50×10^{-2}
	Aroclors	$2.18 \times 10^{+0}$	1.22×10^{-1}
75-01-4	Vinyl Chloride	$3.57 \times 10^{+0}$	2.00×10^{-1}
118-75-2	Chloranil	$1.79 \times 10^{+0}$	$1.00 \times 10^{+0}$
101-77-9	Methylene Dianaline	$1.79 \times 10^{+0}$	$1.00 \times 10^{+0}$
118-74-1	Hexachlorobenzene	$1.81 \times 10^{+1}$	$1.02 \times 10^{+0}$
75-56-9	Propylene Oxide	$2.68 \times 10^{+0}$	$1.50 \times 10^{+0}$
91-22-5	Quinoline	$2.86 \times 10^{+2}$	$1.60 \times 10^{+0}$
7440-38-2	Arsenic Compounds	$2.54 \times 10^{+2}$	$4.06 \times 10^{+0}$
95-53-4	o-Toluidine	$7.86 \times 10^{+0}$	$4.40 \times 10^{+0}$
79-06-1	Acrylamide	$1.07 \times 10^{+2}$	$6.00 \times 10^{+0}$
	PAHs	$1.07 \times 10^{+3}$	$6.00 \times 10^{+0}$
107-06-2	1,2-Dichloroethane	$2.12 \times 10^{+0}$	$1.19 \times 10^{+1}$
62-73-7	Vaponite 2 Insecticide	$1.18 \times 10^{+1}$	$1.89 \times 10^{+1}$
151-50-8	Potassium Cyanide	$3.68 \times 10^{+0}$	$2.06 \times 10^{+1}$
302-01-3	Hydrazine	$5.60 \times 10^{+2}$	$3.13 \times 10^{+1}$
123-91-1	p-Dioxane	$5.63 \times 10^{+0}$	$3.15 \times 10^{+1}$
71-43-2	Benzene	$7.59 \times 10^{+0}$	$4.25 \times 10^{+1}$
7632-00-0	Sodium Nitrite	$1.13 \times 10^{+0}$	$6.30 \times 10^{+1}$
333-41-5	Diazinon	$1.71 \times 10^{+1}$	$9.60 \times 10^{+1}$

Most were located & used in laboratories

The assumed 25% of the annual usage quantity was released into the environment, which was very conservative.

To confirm usage, likelihood of release & quantity of release – the following was obtained from personnel interviews at RFP – Summarized in Appendix L.

A majority of the chemicals were no longer used or had very low annual usage rates. For those chemicals having annual usage rates greater than the inventory quantities, their releases to the env. were estimated to be minimal. Based on the information in Appendix L – it was unlikely for the listed chemicals to pose a significant off-site health hazard – ∴ Limited use lab chemicals were not included in ~~Phase 3~~ Stage 3 chemicals of concern list

Stage 2 identified 46 PCOCs. If sufficient quantities of these chemicals were released they might adversely affect the health of off-site individuals. In stage 3 these chemicals were evaluated to determine their likelihood & relative quantity of release based on their actual storage & normal usage. The routes of release & environmental fate of some chemicals were also evaluated for their potential to result in health impacts.

- Section 3.3.3.1.
- Summary of inventory & usage – Appendix L.

Inventory quantities of arsenic elements were summed prior to comparison with allowable quantity calculated based on toxicity of the element form.

TABLE 3-13

POTENTIAL CHEMICALS OF CONCERN LIST
Group Two: Inventory Quantity > 100 kg — *Probably not impurities in production processes based on quantities (handwritten)*

CAS #	COMPOUND	QUANTITY RATIO	INVENTORY QUANTITY (KG)
7440-43-9	Cadmium Compounds ✓	$6.25 \times 10^{+2}$	$1.00 \times 10^{+2}$
106-99-0	Butadiene	$7.06 \times 10^{+2}$	$1.13 \times 10^{+2}$
50-00-0	Formaldehyde	$2.61 \times 10^{+1}$	$1.46 \times 10^{+2}$
7440-02-0	Nickel Compounds ✓	$1.24 \times 10^{+2}$	$1.99 \times 10^{+2}$
7439-97-6	Mercury Compounds ✓	$2.84 \times 10^{+1}$	$5.69 \times 10^{+2}$
1307-96-6	Cobalt Oxide ✓	$1.21 \times 10^{+0}$	$6.77 \times 10^{+2}$
7440-47-3	Chromium Compounds ✓	$4.95 \times 10^{+4}$	$7.93 \times 10^{+2}$
7647-01-0	Hydrochloric Acid	$2.32 \times 10^{+0}$	$1.30 \times 10^{+3}$
75-09-2	Methylene Chloride	$9.39 \times 10^{+1}$	$1.50 \times 10^{+3}$
7439-96-5	Manganese Compounds ✓	$1.64 \times 10^{+1}$	$2.62 \times 10^{+3}$
127-18-4	Tetrachloroethylene	$7.97 \times 10^{+2}$	$4.46 \times 10^{+3}$
67-66-3	Chloroform	$3.45 \times 10^{+2}$	$5.51 \times 10^{+3}$
7601-90-3	Perchloric Acid	$1.53 \times 10^{+1}$	$8.58 \times 10^{+3}$
7440-41-7	Beryllium Compounds ✓	$1.63 \times 10^{+5}$	$9.14 \times 10^{+3}$
7664-38-2	Phosphoric Acid	$1.80 \times 10^{+0}$	$1.01 \times 10^{+4}$
56-23-5	Carbon Tetrachloride	$2.23 \times 10^{+4}$	$1.25 \times 10^{+4}$
79-01-6	Trichloroethene	$2.73 \times 10^{+3}$	$1.53 \times 10^{+4}$
1310-73-2	Sodium Hydroxide	$2.78 \times 10^{+2}$	$1.56 \times 10^{+4}$
71-55-6	1,1,1-Trichloroethane	$4.06 \times 10^{+0}$	$2.28 \times 10^{+4}$
314-40-9	Bromacil	$4.82 \times 10^{+0}$	$2.70 \times 10^{+4}$
1310-58-3	Potassium Hydroxide	$1.65 \times 10^{+2}$	$9.09 \times 10^{+4}$
75-21-8	Ethylene Oxide	$1.20 \times 10^{+5}$	$1.92 \times 10^{+5}$
7439-92-1	Lead Compounds ✓	$9.00 \times 10^{+2}$	$5.04 \times 10^{+5}$
7664-41-7	Ammonia	$6.23 \times 10^{+0}$	$9.96 \times 10^{+5}$

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Handwritten annotations at right:

Elements discussed in Section 3.3.3.2.2.

Cobalt dropped
Mn dropped

* = Potential animal & human carcinogens were used in large quantities ∴ Considered COCs.

(handwritten "2α" below table)

TABLE 3-18
LIST D CHEMICALS

Compound
N-Nitroso-Di-N-Propylamine
Dibenzofuran
Aroclors
Vinyl Chloride
Chloranil
Methylene Dianaline
Hexachlorobenzene
Quinoline
Arsenic Compounds
o-Toluidine
Acrylamide
PAHs
1,2-Dichloroethane
Vaponite 2 Insecticide
Potassium Cyanide
p-Dioxane
Sodium Nitrite
Diazinon
Cobalt Oxide
Hydrochloric Acid
Manganese Compounds
Perchloric Acid
Phosphoric Acid
Sodium Hydroxide
Bromacil
Potassium Hydroxide
Ammonia

TABLE 3-14

COMPARISON OF 1988/89 AND 1974
INVENTORY QUANTITIES FOR GROUP ONE CHEMICALS

CAS #	Compound	1988/89 Inventory Quantity (kg)	1974 Inventory Quantity (kg)
79-06-1	Acrylamide	0.01	6.000
7440-38-2	Arsenic Compounds	3.06	4.060
71-43-2	Benzene	5.956	42.500
132-64-9y	Dibenzofuran	0.01	0.020
107-06-2	1,2-Dichloroethane	0.006	8.1
123-91-1	p-Dioxane	22.72	9.6
118-74-1	Hexachlorobenzene	1.015	1
302-01-3	Hydrazine	0.5	30.000
101-77-9	Methylene Dianaline	1.00	0.12
151-50-8	Potassium Cyanide	20.592	0.025
91-22-5	Quinoline	1.075	1.600
7632-00-0	Sodium Nitrite	10.628	63.000
95-53-4	o-Toluidine	0.01	4.400
75-01-4	Vinyl Chloride	0.004	0.200

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TABLE 3-13

POTENTIAL CHEMICALS OF CONCERN LIST
Group Two: Inventory Quantity > 100 kg

CAS #	COMPOUND	QUANTITY RATIO	INVENTORY QUANTITY (KG)
7440-43-9	Cadmium Compounds	$6.25 \times 10^{+2}$	$1.00 \times 10^{+2}$
106-99-0	Butadiene	$7.06 \times 10^{+2}$	$1.13 \times 10^{+2}$
50-00-0	Formaldehyde	$2.61 \times 10^{+1}$	$1.46 \times 10^{+2}$
7440-02-0	Nickel Compounds	$1.24 \times 10^{+2}$	$1.99 \times 10^{+2}$
7439-97-6	Mercury Compounds	$2.84 \times 10^{+1}$	$5.69 \times 10^{+2}$
1307-96-6	Cobalt Oxide	$1.21 \times 10^{+0}$	$6.77 \times 10^{+2}$
7440-47-3	Chromium Compounds	$4.95 \times 10^{+4}$	$7.93 \times 10^{+2}$
7647-01-0	Hydrochloric Acid	$2.32 \times 10^{+0}$	$1.30 \times 10^{+3}$
75-09-2	Methylene Chloride	$9.39 \times 10^{+1}$	$1.50 \times 10^{+3}$
7439-96-5	Manganese Compounds	$1.64 \times 10^{+1}$	$2.62 \times 10^{+3}$
127-18-4	Tetrachloroethylene	$7.97 \times 10^{+2}$	$4.46 \times 10^{+3}$
67-66-3	Chloroform	$3.45 \times 10^{+2}$	$5.51 \times 10^{+3}$
7601-90-3	Perchloric Acid	$1.53 \times 10^{+1}$	$8.58 \times 10^{+3}$
7440-41-7	Beryllium Compounds	$1.63 \times 10^{+5}$	$9.14 \times 10^{+3}$
7664-38-2	Phosphoric Acid	$1.80 \times 10^{+0}$	$1.01 \times 10^{+4}$
56-23-5	Carbon Tetrachloride	$2.23 \times 10^{+4}$	$1.25 \times 10^{+4}$
79-01-6	Trichloroethene	$2.73 \times 10^{+3}$	$1.53 \times 10^{+4}$
1310-73-2	Sodium Hydroxide	$2.78 \times 10^{+2}$	$1.56 \times 10^{+4}$
71-55-6	1,1,1-Trichloroethane	$4.06 \times 10^{+0}$	$2.28 \times 10^{+4}$
314-40-9	Bromacil	$4.82 \times 10^{+0}$	$2.70 \times 10^{+4}$
1310-58-3	Potassium Hydroxide	$1.65 \times 10^{+2}$	$9.09 \times 10^{+4}$

75-21-8	Ethylene Oxide	$1.20 \times 10^{+5}$	$1.92 \times 10^{+5}$
7439-92-1	Lead Compounds	$9.00 \times 10^{+2}$	$5.04 \times 10^{+5}$
7664-41-7	Ammonia	$6.23 \times 10^{+0}$	$9.96 \times 10^{+5}$

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TABLE 3-3

INHALATION EXPOSURE (CARCINOGENIC EFFECT)

It is conservatively assumed that the receptor is at the fence line, exposed 24 hr/day and 365 days/year. The slope factor is defined as the increase of cancer risk over a life-time per unit dose in mg/kg/day.

Increase of Cancer Risk	Slope Factor $(mg/kg/day)^{-1}$	Concentration in Inhaled Air (mg/m^3)	Allowable Emission Rate (kg/yr)	Allowable Inventory Quantity (kg)
1×10^{-6}	100,000	3.5×10^{-11}	4.1×10^{-5}	1.6×10^{-5}
1×10^{-6}	10,000	3.5×10^{-10}	4.1×10^{-4}	1.6×10^{-4}
1×10^{-6}	1,000	3.5×10^{-9}	4.1×10^{-3}	1.6×10^{-3}
1×10^{-6}	100	3.5×10^{-8}	4.1×10^{-2}	1.6×10^{-2}
1×10^{-6}	10	3.5×10^{-7}	4.1×10^{-1}	1.6×10^{-1}
1×10^{-6}	1	3.5×10^{-6}	4.1×10^{0}	1.6×10^{0}
1×10^{-6}	0.1	3.5×10^{-5}	4.1×10^{1}	1.6×10^{1}
1×10^{-6}	0.01	3.5×10^{-4}	4.1×10^{2}	1.6×10^{2}
1×10^{-6}	0.001	3.5×10^{-3}	4.1×10^{3}	1.6×10^{3}
1×10^{-6}	0.0001	3.5×10^{-2}	4.1×10^{4}	1.6×10^{4}

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TABLE 3-4

INHALATION EXPOSURE (NON-CARCINOGENIC EFFECT)

It is conservatively assumed that the receptor was at the fence line and exposed 24 hr/day. The RfD is defined as the amount of a chemical to which an individual can be exposed on a daily basis over a lifetime without appreciable health risk.

RfD (mg/kg/day)	Concentration in Inhaled Air (mg/m^3)	Allowable Emission Rate (kg/yr)	Allowable Inventory Quantity (kg)
1×10^{-5}	3.5×10^{-5}	4.1×10^1	1.6×10^1
1×10^{-4}	3.5×10^{-4}	4.1×10^2	1.6×10^2
1×10^{-3}	3.5×10^{-3}	4.1×10^3	1.6×10^3
1×10^{-2}	3.5×10^{-2}	4.1×10^4	1.6×10^4
1×10^{-1}	3.5×10^{-1}	4.1×10^5	1.6×10^5
1	3.5×10^0	4.1×10^6	1.6×10^6
$1 \times 10^{+1}$	3.5×10^1	4.1×10^7	1.6×10^7

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TABLE 3-5

DRINKING WATER EXPOSURE (CARCINOGENIC EFFECT)

It is conservatively assumed that the receptor obtains all his/her drinking water from a contaminated source.

Increase of Cancer Risk	Slope Factor $(mg/kg/day)^{-1}$	Concentration in Drinking Water (mg/l)	Allowable Release Rate (kg/yr)	Allowable Inventory Quantity (kg)
1×10^{-6}	100,000	3.5×10^{-10}	1.4×10^{-5}	5.6×10^{-6}
1×10^{-6}	10,000	3.5×10^{-9}	1.4×10^{-4}	5.6×10^{-5}
1×10^{-6}	1,000	3.5×10^{-8}	1.4×10^{-3}	5.6×10^{-4}
1×10^{-6}	100	3.5×10^{-7}	1.4×10^{-2}	5.6×10^{-3}
1×10^{-6}	10	3.5×10^{-6}	1.4×10^{-1}	5.6×10^{-2}
1×10^{-6}	1	3.5×10^{-5}	1.4×10^{0}	5.6×10^{-1}
1×10^{-6}	0.1	3.5×10^{-4}	1.4×10^{1}	5.6×10^{0}
1×10^{-6}	0.01	3.5×10^{-3}	1.4×10^{2}	5.6×10^{1}
1×10^{-6}	0.001	3.5×10^{-2}	1.4×10^{3}	5.6×10^{2}
1×10^{-6}	0.0001	3.5×10^{-1}	1.4×10^{4}	5.6×10^{3}

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TABLE 3-6

DRINKING WATER EXPOSURE (NON-CARCINOGENIC EFFECT)

It is conservatively assumed that the receptor obtains all his/her drinking water from a contaminated source.

RfD (mg/kg/day	Concentration in Drinking Water (mg/l)	Allowable Release Rate (kg/yr)	Allowable Inventory Quantity (kg)
1×10^{-5}	3.5×10^{-4}	1.4×10^{1}	5.6×10^{0}
1×10^{-4}	3.5×10^{-3}	1.4×10^{2}	5.6×10^{1}
1×10^{-3}	3.5×10^{-2}	1.4×10^{3}	5.6×10^{2}
1×10^{-2}	3.5×10^{-1}	1.4×10^{4}	5.6×10^{3}
1×10^{-1}	3.5×10^{0}	1.4×10^{5}	5.6×10^{4}
1	3.5×10^{1}	1.4×10^{6}	5.6×10^{5}
1×10^{1}	3.5×10^{2}	1.4×10^{7}	5.6×10^{6}

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TABLE 3-10

SUBSTANCES TO BE EVALUATED FOR
MULTI-PATHWAY EXPOSURES

Arsenic
Beryllium
Cadmium
Chromium (hexavalent)
Dioxins/Dibenzofurans (as TCDD equivalents)
Lead
Mercury
Nitrosamines:
N-Nitrosodiethylamine
N-Nitrosodimethylamine
N-Nitrosodiphenylamine
N-Nitrosodi-n-butylamine
PAHs (Polycyclic aromatic hydrocarbons) including but not limited to:
Benz(a)anthracene
Benzo(b)fluoranthene
Benzo(k)fluoranthene
Benzo(a)pyrene
Dibenz(a,h)anthracene

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TABLE 3-8

PAHs IDENTIFIED IN 1974 AND 1988/89 INVENTORIES

PAH Name	1988/89 Quantity (kg)	1974 Quantity (kg)
Acenaphthene	0.015	0.02
Anthracene	0.115	0.52
Benzo(a)pyrene	0.002	NR
Chrysene	0.005	NR
Fluoranthene	0.015	0.12
Fluorene	0.015	0.02
Naphthalene	0.922	1.8
Pyrene	0.017	0.02
TOTAL QUANTITY (kg)	1.106	2.5

NR = Not recorded

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APPENDIX E

REPRODUCTIVE AND DEVELOPMENTAL TOXICANTS

Carbon Disulfide[1]
Carbon Monoxide[1]
Coumarin[2]
Dinitrobenzene[1]
Ethylene Glycol Monoethyl Ether[1]
Ethylene Glycol Monomethyl Ether[1]
Hexachlorobenzene[1]
Lithium[2]
Lead[1,2]
Mercury and Mercury Compounds[1,2]
PCBs[2]
Ethylene Oxide[1]

1 CHWA, 1989
2 Shepard, 1989

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TABLE 3-11

FACTORS THAT MAY OVERESTIMATE OR UNDERESTIMATE
POTENTIAL HEALTH HAZARD POSED BY A
CHEMICAL EVALUATED IN STAGE 1 AND 2 SCREENING

Factors That May Overestimate Potential Health Hazard	Factors That May Underestimate Potential Health Hazard
_Chemicals in solution were conservatively assumed to be pure chemical. This may over-estimate the inventory quantity by a factor of 10 to 100.	_RfDs derived from oral LD$_{50}$s were used to evaluate health hazards from both drinking water and inhalation exposure routes. It is possible that for certain chemicals, the inhalation route has a lower RfD than the oral route.
_For some inorganic compounds, only the cation or anion is considered toxic. Rather than calculating the exact amount of the ion of concern, its quantity is conservatively assumed to be equal to the quantity of the compound. For example, 8 kg of potassium dichromate is evaluated as 8 kg of chromium. Furthermore, to be extremely conservative, it is also assumed that all the chromium ions are in the +6 valence state.	_Potential synergistic effects of exposure to multiple chemicals was not considered in this screening exercise. Similarly, potential antagonistic effects of exposure to multiple chemicals was not considered. The current state-of-knowledge of synergistic and antagonistic effects is very limited.
_For all of the chemicals considered, it was conservatively assumed that 25% of the inventory quantity was released into both the air and drinking water. The actual percentage of release for most of the chemicals is expected to be much less due to	_Some compounds may degrade or react with other chemicals in the environment and form products that can be more toxic or less toxic than the parent compound. The potential health impact of this type of chemical transformation has not been addressed in this

their physical state (non-volatiles, insolubles, etc.), means of storage (e.g., stored in bottles, vials, etc.) and usage. The only exception may be volatile compounds for which, under certain situations, nearly 100% may be eventually released into the environment.	screening procedure.
_Several conservative assumptions were used in the application of the air dispersion model, SCREEN. First, it was assumed that the off-site receptor was at the fence line of the RFP and was exposed 24 hr/day, 365 days/year for a lifetime. Second, for a given emission rate, the meteorological condition that results in the highest one-hour average air concentration at the fence line was used to calculate the annual average air concentration. Furthermore, it was assumed that this worst-case exposure scenario was sustained over the entire lifetime of the receptor. For the non-volatile chemicals, it was assumed that they could be released to the air as particulates. The effect of deposition which would reduce downwind concentrations was not taken into account by the dispersion model. These conservative assumptions may over-estimate the amount of a chemical inhaled by an off-site individual by a factor of 100 to 10,000.	_Only chronic adverse health effects were considered in this screening exercise. Possible acute health effects due to episodic releases were not included, but would be evaluated as part of any characterization of accidents or incidents.
_Several conservative assumptions were used in calculating the concentration of a chemical in drinking water. Regardless of solubility, it was conservatively assumed that 25% of the assumed annual consumption was dissolved in the Great Western Reservoir. This reservoir was chosen over Standley Lake because it has a smaller capacity, receives any releases from the RFP waste treatment plant and holding ponds and is closer to the RFP site. It was also assumed that the chemical was discharged into the water in a single event, although it is more likely that any discharge would have been gradual and maintained over a period of time. It was also assumed that the chemical was discharged directly into the water. These conservative assumptions may over-estimate the amount of a chemical ingested by an off-site individual through drinking water by a factor of 100 to 1000.	
_When no RfD was located for a chemical, a derived RfD is calculated from its oral LD_{50}. This approach conservatively assumed that the	

severity of the toxic effect being considered is proportional to the dose. Many irritants and compounds that represent essential nutrients may have a high threshold and this no threshold approach may be too conservative.	
_In implementing Stage 2 screening, only a limited number of toxicity criteria (order-of-magnitude) were listed in the screening tables. In calculating the required quantity, the most conservative criteria was always used.	

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TOXICITY CRITERIA AND ALLOWABLE
QUANTITIES DETERMINED FOR SOME ACIDS AND BASES

Compound	Toxicity Criteria (mg/kg/day)		Allowable Quality (Kg)	Actual Quantity (Kg)	Quantity Ratio
Sodium Hydroxide	$LD_{50}/1000$	0.04	5,600	15,577.007	2.78
Potassium Hydroxide	$LD_{50}/1000$	0.273	56,000	92,155.547	1.65
Perchloric Acid	$LD_{50}/1000$	0.4	56,000	8,581.000	0.15
Hydrochloric Acid	$LD_{50}/1000$	0.9	56,000	1,300.000	0.023
Phosphoric Acid	$LD_{50}/1000$	1.53	560,000	10,100.000	0.018
Ammonia	RfD(i)	0.1	160,000	996,000.000	6.23
Ammonia	RfD(o)	1.0	160,000	996,000.000	6.23

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